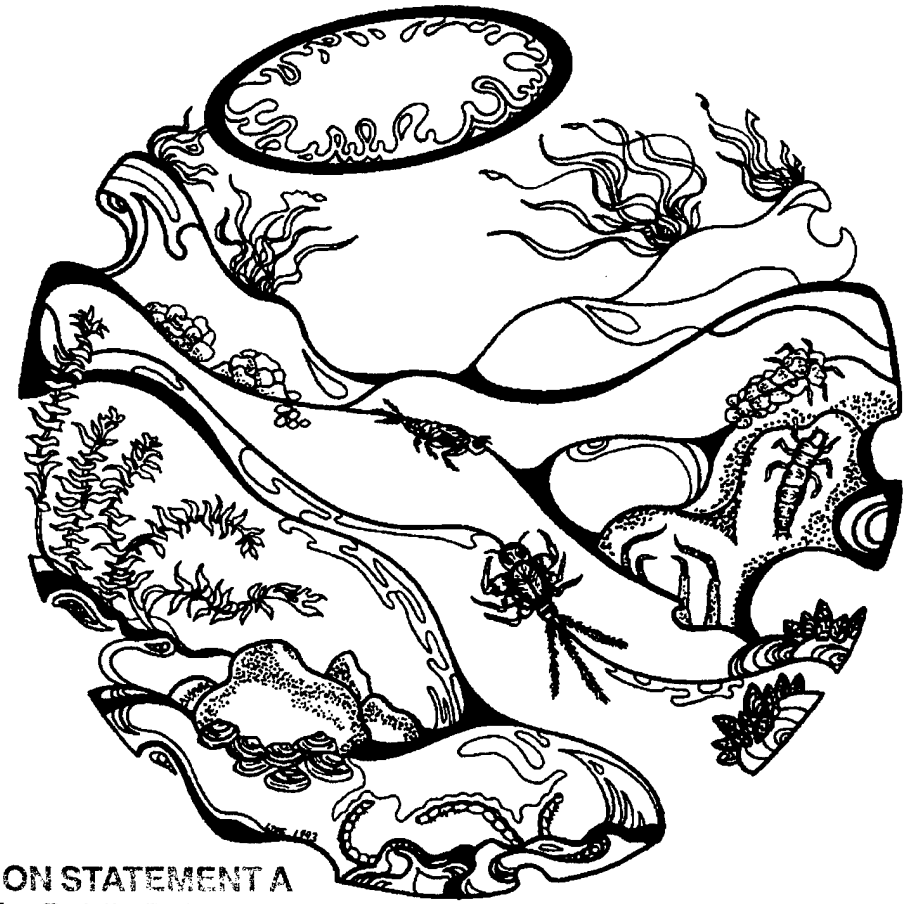
Long Term Resource Monitoring Program

Program Report

2000-P001 (Revised 2000)

Long Term Resource Monitoring Program Annual Status Report, 1999: Macroinvertebrate Sampling in Six Reaches of the Upper Mississippi River System



Revised August 2000

The Upper Midwest Environmental Sciences Center issues LTRMP Program Reports to provide Long Term Resource Monitoring Program partners with programmatic documentation, procedures manuals, and annual status reports.

Upper Midwest Environmental Sciences Center

CENTER DIRECTOR
Leslie E. Holland-Bartels

PROGRAM MANAGER
Robert L. Delaney

CHIEF, AQUATIC SCIENCES BRANCH
James G. Wiener

CHIEF, SUPPORT SERVICES
Barbara A. Deml

REPORT EDITOR
Deborah K. Harris

Cover graphic by MiAe Lipe-Butterbrodt

Long Term Resource Monitoring Program Annual Status Report, 1999: Macroinvertebrate Sampling in Six Reaches of the Upper Mississippi River System

by

Jennifer S. Sauer

August 2000

U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603

Suggested citation:

Sauer, J. 2000. Long Term Resource Monitoring Program annual status report, 1999: Macroinvertebrate sampling in six reaches of the Upper Mississippi River System. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, August 2000 (Revised 2000). LTRMP 2000-P001. 21 pp.

Additional copies of this report may be obtained from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (1-800-553-6847 or 703-487-4650). Also available to registered users from the Defense Technical Information Center, Attn: Help Desk, 8725 Kingman Road, Suite 0944, Fort Belvoir, VA 22060-6218 (1-800-225-3842 or 703-767-9050).

Contents

Page

Preface vii

Abstract 1

Introduction 1

Methods 2
- Sampling Procedures 2
- Site Information 3
- Statistical Analyses 3

Summary 3

Acknowledgments 4

References 4

Tables

Page

1. Numbers of random sample sites for macroinvertebrates, by study reach and aquatic area 6
2. Dates of macroinvertebrate sampling in 1999 6
3. Estimated mean numbers of mayflies, fingernail clams, midges, Asiatic clams, and zebra mussels per square meter by year and study area, weighted by areas of strata 7
4. Mean number of mayflies per square meter by study reach and aquatic area 8
5. Mean number of fingernail clams per square meter by study reach and aquatic area 8
6. Mean number of midges per square meter by study reach and aquatic area 9
7. Mean number of zebra mussels per square meter by study reach and aquatic area 9
8. Percentage of predominant substrate type found in Ponar grab samples by study reach 10
9. Mean numbers of selected taxa per square meter by predominant substrate type, all study areas combined 10

Figures

Page

1. Long Term Resource Monitoring Program study reaches for macroinvertebrate sampling 11

2. Pool 4 (Mississippi River miles 753–797)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points 12

3. Pool 8 (Mississippi River miles 679–703)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points 13

4. Pool 13 (Mississippi River miles 522.5–557)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points 14

5. Pool 26 (Mississippi River miles 203–241.5)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points 15

6. Open River (Mississippi River miles 0–80)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points 16

7. La Grange Pool (Illinois River miles 80–158)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points 17

8. Estimated density of Ephemeridae (number m^{-2}) by study area, weighted by area of strata 18

9. Estimated density of Sphaeriidae (number m^{-2}) by study area, weighted by area of strata 19

10. Estimated density of Chironomidae (number m^{-2}) by study area, weighted by area of strata 20

11. Percentage of times (all sample sites) that the taxa were recorded 21

Preface

The Long Term Resource Monitoring Program (LTRMP) was authorized under the Water Resources Development Act of 1986 (Public Law 99-662) as an element of the U.S. Army Corps of Engineers Environmental Management Program. The LTRMP is being implemented by the Upper Midwest Environmental Sciences Center, a U.S. Geological Survey science center, in cooperation with the five Upper Mississippi River System (UMRS) States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The U.S. Army Corps of Engineers provides guidance and has overall Program responsibility. The mode of operation and respective roles of the agencies are outlined in a 1988 Memorandum of Agreement.

The UMRS encompasses the commercially navigable reaches of the Upper Mississippi River, as well as the Illinois River and navigable portions of the Kaskaskia, Black, St. Croix, and Minnesota Rivers. Congress has declared the UMRS to be both a nationally significant ecosystem and a nationally significant commercial navigation system. The mission of the LTRMP is to provide decision makers with information for maintaining the UMRS as a sustainable large river ecosystem, given its multiple-use character. The long-term goals of the Program are to understand the system, determine resource trends and effects, develop management alternatives, manage information, and develop useful products.

This document is an annual summary for 1999, containing a summary of target macroinvertebrate populations in the UMRS. This report satisfies, for 1999, Task 2.2.7.4, *Evaluate and Summarize Annual Results* under Goal 2, *Monitor Resource Change*, as specified in the Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program (U.S. Fish and Wildlife Service 1993). This report was developed with funding provided by the Long Term Resource Monitoring Program.

Long Term Resource Monitoring Program Annual Status Report, 1999: Macroinvertebrate Sampling in Six Reaches of the Upper Mississippi River System

by

Jennifer S. Sauer
U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603

Abstract: In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, and the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program. Long-term monitoring is needed to detect population trends and local changes in aquatic ecosystems. Mayflies (Ephemeridae), fingernail clams (Sphaeriidae), and the exotic Asiatic clam (*Corbicula*) were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) in 1995. Mayflies, fingernail clams, and midges, members of the soft-substrate community, were chosen because they play an important ecological role in the Upper Mississippi River System. Sampling was based on a stratified random design and was conducted at about 125 sites per study area. Mean densities of taxa were weighted by strata for extrapolation purposes. Pool 8 had the highest estimated mean densities of mayflies and fingernail clams (215 and 505 m^{-2}, respectively). Pool 13 had the highest estimated mean number of midges (234 m^{-2}). Overall, the impounded areas (including Lake Pepin) and the contiguous backwaters tended to support the highest mean densities of mayflies, fingernail clams, and midges. Substrates with predominantly a silt clay constituent supported the highest mean densities of mayflies, fingernail clams, and midges.

Key words: Benthic aquatic macroinvertebrates, *Corbicula*, fingernail clams (Sphaeriidae), mayflies (Ephemeridae), midges (Chironomidae), Mississippi River, zebra mussels (*Dreissena polymorpha*)

Introduction

In 1986, Congress designated the Upper Mississippi River System (UMRS), which consists of the Upper Mississippi and Illinois Rivers and several important tributaries, as a nationally significant ecosystem and a nationally significant navigation system. In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program (LTRMP). Mayflies (Ephemeridae), fingernail clams (Sphaeriidae), and the exotic Asiatic clam (*Corbicula*) were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and the exotic zebra mussel (*Dreissena polymorpha*) in 1995. Mayflies, fingernail clams, and midges, part of the soft-sediment substrate fauna, were chosen as target organisms for the LTRMP because of their important ecological role in the UMRS. For example, Thompson (1973) found that in fall, lesser scaup (*Aythya affinis*) gizzard contents contained 76% sphaeriids and about 13% mayflies. Thompson also found the target organisms to be important to canvasbacks (*Aythya valisneria*), ring-necked ducks (*Aythya collaris)*, and American coots (*Fulica americana*) feeding in open water. A number of fish, including commercial and recreational species, utilize the target organisms (Hoopes 1960; Jude 1968; Ranthum 1969). Researchers have also traditionally used macroinvertebrates as biological indicators of river water quality (Myslinski and Ginsburg 1977; Rosenberg and Resh 1992). An indicator species can be defined as a species that has particular requirements with regard to a known set of physical or chemical parameters. Mayflies, fingernail clams, and midges have been historically used as indicators of river water quality (Fremling 1964, 1973, 1989; Steingraber and Wiener 1995). Macroinvertebrates also perform an important ecological function by digesting organic material and recycling nutrients (Reice and Wohlenberg 1992). Asiatic clams and

zebra mussels were chosen for sampling because of their potential adverse effects on the economy and biology of the UMRS (Tucker 1995a,b).

The objective of the LTRMP macroinvertebrate component is to annually monitor and report trends in the status and distribution of key macroinvertebrate populations. The LTRMP macroinvertebrate staff collects basic information on macroinvertebrates on the UMRS to aid in the interpretation or prediction of long- and short-term patterns. The publicly available data and annual status reports are the most basic LTRMP products. These annual status reports provide more detailed summaries of macroinvertebrate data than those contained in trend reports (Sauer 1998). The ultimate goal of the LTRMP is not simply to report status and trends, but to improve the understanding and management of the UMRS. That goal can best be achieved by the integration of routine monitoring with experimental research directed at identifying the causes of and solutions to specific problems. Future LTRMP studies will integrate more narrowly focused analyses of data from all LTRMP monitoring components (limnology, bathymetry, sediments, aquatic plants, and fisheries) with results of experimental studies to identify causes of problems and opportunities for improved management. The resulting syntheses will be the ultimate products of the LTRMP.

The present report summarizes macroinvertebrate monitoring at each of the LTRMP field stations during spring 1999. This report documents sampling methods and presents macroinvertebrate densities.

Methods

Sampling Procedures

Macroinvertebrate sampling procedures are described in detail in the LTRMP Procedures Manual (Thiel and Sauer 1999). The sampling of mayflies, fingernail clams, midges, Asiatic clams, and zebra mussels was conducted during 1999 in Pools 4, 8, 13, 26, the Open River Reach of the Mississippi River, and in La Grange Pool of the Illinois River (Figure 1). The presence or absence of Odonata, Plecoptera, Trichoptera, Diptera, Bivalvia, Oligochaeta, Decapoda, Amphipoda, and Gastropoda was also reported.

Annual sampling was conducted at about 125 sites per study area (Table 1; Figures 2–7). Sample allocation was based on several criteria, including surface area of the aquatic area in each study reach, accessibility, and the productivity of the taxa in each aquatic area. All sites were sampled in early spring 1999 (Table 2), before emergence of mayflies and much growth of vegetation occurs.

Sites included locations where benthic samples were collected historically (i.e., sites where benthic samples were collected by previous researchers) and randomly selected sites distributed among key aquatic areas, which are based on enduring geomorphic features (Wilcox 1993). Aquatic areas sampled included contiguous backwaters, which have apparent surface water connection with the rest of the river; main channel borders, the area between the navigational buoys and the riverbank—not including revetments and channel-training structures; impounded areas, large, mostly open-water areas located in the downstream portion of the navigation pools; and side channels, channels that carry less flow than the navigation channel. For Pool 4, the impounded area is in the form of Lake Pepin, a tributary delta lake formed by the Chippewa River delta. In the present report, only data from the randomly selected sites are discussed.

The LTRMP developed a spatial database of aquatic areas (Owens and Ruhser 1996) on the basis of aerial photography produced in 1989; this database was used for randomized selection of sampling sites and the quantification of sampling strata.

Benthic samples were collected with a winch-mounted 23- × 23-cm (0.052-m^2) standard Ponar grab sampler (Ponar Grab Dredge, Wildlife Supply Company, Saginaw, Michigan). Samples were washed through a U.S. Standard No. 16 (1.18 mm) mesh that retained only the larger taxa and life stages of the invertebrate community. Mayflies, fingernail clams, midges (greater than 1 cm), Asiatic clams, and zebra mussels were removed from each sample and enumerated.

Site Information

Field crews qualitatively characterized each sampling site. Substrate composition in the Ponar samples were classified into one of six categories of substrate: hard clay, silt clay, silt clay with sand, sand with silt clay, sand, and gravel rock. The percentage of submersed and floating-leaved aquatic vegetation in the column of water and sediment that the Ponar dredge fell through was recorded. Also, the type and percentage of vegetation and open water in a 15-m radius from the boat were characterized. Water depth was also measured at each site.

Statistical Analyses

Total catch was recorded for each target taxa from individual Ponar samples. If a species was not present in a sample, the catch for that species in that sample was tabulated as zero.

The areawide estimated mean number of taxa in the present report was based on estimates of mean densities obtained by pooling data over all strata selected for macroinvertebrate sampling (Sauer 1998). These estimates track relative densities at the broadest possible spatial scale and can be used to evaluate areawide trends in abundance. If the quantity of preferred habitats declines through time while densities in those preferred habitats remains constant, then these pooled mean density statistics should also reflect that decline. The LTRMP monitors both the composition of aquatic areas and macroinvertebrates. Therefore, if the quantity of that aquatic area class preferred by a particular species declines through time while the abundances within each aquatic area remain constant, then the pooled mean density statistics should also reflect the resulting decline in reachwide abundance, whereas mean density statistics from only the preferred aquatic area would not.

The estimates of pooled reachwide mean densities were obtained from the conventional design-based estimator for stratified random samples (Cochran 1977). For an arbitrary random variable denoted y (for this report y is density), the pooled mean, denoted $\bar{y}_{st}$ (st for stratified) is given by

$$\bar{y}_{st} = \frac{1}{N}\sum_{h=1}^{L} N_h \bar{y}_h \qquad (1)$$

where N_h is the number of sampling sites within stratum h, $N = \Sigma_{h=1}^{L} N_h$, and $\bar{y}_h$ denotes the estimator of the sample mean of y for stratum h. The estimator of the variance of $\bar{y}_{st}$ is

$$s^2(\bar{y}_{st}) = \frac{1}{N^2}\sum_{h=1}^{L} N_h(N_h - n_h)\left(\frac{s_h^2}{n_h}\right) \qquad (2)$$

where

$$s_h^2 = \frac{\sum_{i=1}^{n_h} (y_{hi} - \bar{y}_h)^2}{n_h - 1}$$

is the usual estimator of the variance of y_h and n_h is the number of samples taken in stratum h (Cochran 1977). The standard error of $\bar{y}_{st}$ is therefore $s(\bar{y}_{st})$. Equation (1) is used to obtain estimates of overall mean densities for stratified random sampling. In random samples, equation (1) yields unbiased estimates of the pooled means regardless of the probability distribution of y (Cochran 1977). For LTRMP macroinvertebrate monitoring, the sampling units are the 50-m^2 sampling grids.

Summary

- Measured depths at sampling sites ranged from 0.2 to 12.6 m, with a mean of 3.1 m.
- In all study reaches, more than 85% of the Ponar grabs contained no submersed or floating-leaved vegetation. Most samples in all study areas were in open water with little vegetation.
- Macroinvertebrate sampling (N = 665) in 1999 produced a total of 2,853 mayflies, 4,060 fingernail clams, 3,191 midges, 18 Asiatic clams, and 4,986 zebra mussels.
- Mean densities of target taxa were weighted by strata selected for macroinvertebrate sampling (Sauer 1998) to estimate poolwide or reachwide

means (Table 3; Figures 8–10). Pool 8 had the highest estimated mean numbers of mayflies and fingernail clams. Pool 13 had the highest densities of midges. Increases in the estimated mean number of mayflies between 1998 and 1999 were seen in Pools 8, 13, and 26. Pools 4 and 8 showed increases in densities of fingernail clams, whereas fingernail clams declined in Pools 13, 26, and La Grange Pool. No fingernail clams were found in the Open River study area. Increases in midge densities were seen in Pools 13 and 26 and in the Open River study area.

- Numbers of Asiatic clams were low in all study areas. Zebra mussel densities were highest in Pools 8 and 13 with some Ponar grab samples containing more than 500 individual zebra mussels (equivalent to 9,615 m^{-2}).

- The impounded aquatic areas in Pools 4 (Lake Pepin) and 13 supported the highest numbers of mayflies (Table 4). Though the standard error was high, side channel areas in Pool 8 had the highest densities of mayflies.

- Mean densities of fingernail clams were greatest in Lake Pepin (Pool 4) and the impounded areas of Pools 8, 13, and 26. The greatest densities of fingernail clams in La Grange Pool were found in the side channel aquatic areas (Table 5).

- The backwater contiguous areas in Pools 13, 26, and La Grange Pool had higher densities of midges than other aquatic areas (Table 6). In Pool 4, Lake Pepin had the highest density of midges.

- The impounded areas had the highest densities of zebra mussels in Pools 4, 8, and 13 (Table 7). Low numbers of zebra mussels were found in La Grange Pool—only one individual was found during stratified random sampling ($N = 98$).

- Visual classification of sediments indicated that sample sites in Pools 4, 8, 13, 26, and La Grange Pool were predominantly silt clay (Table 8). Sampled substrates in the Open River study area were mostly sand.

- Overall, the silt clay and silt clay with sand substrates supported the highest mean numbers of mayflies, fingernail clams, and midges (Table 9). Not surprisingly, the highest densities of zebra mussels were found on the gravel rock substrates.

- Oligochaeta (aquatic worms and leeches) were the only taxa that were present more times than they were absent; 58% of the samples contained oligochaetes (Figure 11).

Acknowledgments

The LTRMP is a cooperative effort involving the U.S. Geological Survey, the U.S. Army Corps of Engineers, the Illinois Department of Conservation, the Illinois Natural History Survey, the Iowa Department of Natural Resources, the Minnesota Department of Natural Resources, the Missouri Department of Conservation, and the Wisconsin Department of Natural Resources. Monitoring is conducted by the participating state resource management and research agencies. The author thanks these agencies and the participating field station staff.

References

Cochran, W. G. 1977. Sampling techniques. Third edition. John Wiley & Sons, New York. 428 pp.

Fremling, C. R. 1964. Mayfly distribution indicates water quality on the Upper Mississippi River. Science 146:1164–1166.

Fremling, C. R. 1973. Factors influencing the distribution of burrowing mayflies along the Mississippi River. Pages 12–15 *in* W. L. Peters and J. G. Peters, editors. Proceedings of the First International Conference on Ephemeroptera. E. J. Brill Publishers, Leiden, The Netherlands.

Fremling, C. R. 1989. *Hexagenia* mayflies: Biological monitors of water quality in the Upper Mississippi River. Journal of the Minnesota Academy of Science 55:139–143.

Hoopes, D. T. 1960. Utilization of mayflies and caddisflies by some Mississippi River fishes. Transactions of the American Fisheries Society 89:32–34.

Jude, D. J. 1968. Bottom fauna utilization and distribution of ten species of fish in Pool 19, Mississippi River. M.S. Thesis, Iowa State University, Ames. 238 pp.

Myslinski, E., and W. Ginsburg. 1977. Macroinvertebrates as indicators of pollution. American Water Works Association Journal 69:538–544.

Owens, T., and J. J. Ruhser. 1996. Long Term Resource Monitoring Program standard operating procedures: Aquatic areas database production. National Biological Service, Environmental Management Technical Center, Onalaska, Wisconsin, March 1996. LTRMP 95-P008-6. 4 pp. + Appendix (NTIS # PB96-172267)

Ranthum, R. G. 1969. Distribution and food habits of several species of fish in Pool 19, Mississippi River. M.S. Thesis, Iowa State University, Ames. 207 pp.

Reice, S. R., and M. Wohlenberg. 1992. Monitoring freshwater benthic macroinvertebrates and benthic processes: Measures for assessment of ecosystem health. Pages 287–305 *in* Freshwater biomonitoring and benthic macroinvertebrates, D. M. Rosenberg and V. H. Resh, editors. Chapman and Hall, New York.

Rosenberg, D. M., and V. H. Resh. 1992. Freshwater biomonitoring and benthic macroinvertebrates. Chapman and Hall, New York.

Sauer, J. 1998. Temporal analyses of select macroinvertebrates in the Upper Mississippi River System, 1992–1995. U.S. Geological Survey, Environmental Management Technical Center, Onalaska, Wisconsin, April 1998. LTRMP 98-T001. 26 pp. + Appendix (NTIS # PB98-140874)

Steingraber, M. T., and J. G. Wiener. 1995. Bioassessment of contaminant transport and distribution in aquatic ecosystems by chemical analysis of burrowing mayflies (*Hexagenia*). Regulated Rivers: Research & Management 11:201–209.

Thiel, P. A., and J. S. Sauer. 1999. Long Term Resource Monitoring Program Procedures: Macroinvertebrate monitoring. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, Revised May 1999. LTRMP 95-P002-2 (Revised 1999). 7 pp. + Appendixes A-H

Thompson, D. 1973. Feeding ecology of diving ducks on Keokuk Pool, Mississippi River. Journal of Wildlife Management 37:367–381.

Tucker, J. K. 1995a. Colonization of unionid bivalves by the zebra mussel, *Dreissena polymorpha*, in Pool 26 of the Mississippi River. Journal of Freshwater Ecology 9:129–134.

Tucker, J. K. 1995b. Windrow formation of two snails (families Viviparidae and Pleuroceridae) colonized by the exotic zebra mussel, *Dreissena polymorpha*. Journal of Freshwater Ecology 9:85–86.

U.S. Fish and Wildlife Service. 1993. Operating Plan for the Upper Mississippi River System Long Term Resource Monitoring Program. Environmental Management Technical Center, Onalaska, Wisconsin, Revised September 1993. EMTC 91-P002R. 179 pp. (NTIS #PB94-160199)

Wilcox, D. B. 1993. An aquatic habitat classification system for the Upper Mississippi River System. U.S. Fish and Wildlife Service, Environmental Management Technical Center, Onalaska, Wisconsin, May 1993. EMTC 93-T003. 9 pp. + Appendix A (NTIS # PB93-208981)

Table 1. Numbers of random sample sites for macroinvertebrates, by study reach and aquatic area. Numbers in parenthesis are historical (fixed) sites.

Study reach	Contiguous backwater	Impounded	Side channel	Main channel border
Pool 4	55 (3)	44 (1)[a]	10	11
Pool 8	31 (3)	47 (11)	19 (2)	10
Pool 13	43 (2)	46 (1)	14 (4)	15
Pool 26	37	27	33 (3)	17 (4)
Open River	—	—	65 (15)	43 (2)
La Grange Pool	24 (18)	—	35 (7)	39 (1)

[a]Pool 4 Impounded = Lake Pepin, Tributary Delta Lake

Table 2. Dates of macroinvertebrate sampling in 1999.

Study reach	Beginning date	Ending date
Pool 4	May 5	May 14
Pool 8	May 7	May 19
Pool 13	May 17	May 28
Pool 26	April 9	April 22
Open River	March 29	April 9
La Grange Pool	May 3	May 14

Table 3. Estimated mean numbers of mayflies, fingernail clams, midges, Asiatic clams, and zebra mussels per square meter by year and study area, weighted by areas of strata. *N* = number of samples.

Study area and year (*N*)	Mayflies (±1 SE)	Fingernail clams (±1 SE)	Midges (±1 SE)	Asiatic clams (±1 SE)	Zebra mussels (±1 SE)
Pool 4					
1992 (122)	59 (18)	47 (19)	—	0 (0)	—
1993 (121)	128 (36)	74 (11)	318 (39)	0 (0)	—
1994 (126)	203 (50)	88 (12)	185 (32)	0 (0)	—
1995 (120)	178 (36)	61 (13)	82 (13)	0 (0)	27 (27)
1996 (121)	132 (34)	39 (7)	38 (11)	0 (0)	116 (113)
1997 (120)	69 (21)	76 (9)	152 (35)	0 (0)	31 (28)
1998 (121)	209 (44)	73 (10)	253 (39)	0 (0)	107 (98)
1999 (120)	69 (18)	138 (21)	199 (33)	0 (0)	38 (33)
Pool 8					
1992 (109)	51 (25)	15 (11)	—	0 (0)	—
1993 (109)	118 (41)	22 (11)	50 (9)	0 (0)	—
1994 (110)	91 (31)	11 (5)	27 (16)	0 (0)	—
1995 (109)	56 (14)	6 (3)	11 (4)	0 (0)	0 (0)
1996 (109)	38 (11)	2 (1)	15 (4)	0 (0)	1 (0)
1997 (112)	71 (16)	9 (4)	26 (6)	0 (0)	25 (11)
1998 (109)	120 (36)	27 (8)	82 (19)	0 (0)	26 (17)
1999 (107)	215 (58)	505 (158)	45 (15)	0 (0)	292 (132)
Pool 13					
1992 (118)	120 (31)	84 (28)	—	0 (0)	—
1993 (119)	155 (39)	2,596 (494)	509 (95)	0 (0)	—
1994 (125)	194 (36)	594 (157)	75 (34)	0 (0)	—
1995 (118)	182 (52)	276 (82)	40 (9)	0 (0)	10 (7)
1996 (118)	147 (38)	231 (58)	21 (7)	0 (0)	14 (8)
1997 (118)	165 (43)	87 (23)	79 (36)	0 (0)	562 (448)
1998 (118)	167 (45)	150 (34)	80 (28)	0 (0)	120 (93)
1999 (118)	187 (46)	145 (33)	234 (75)	0 (0)	529 (321)
Pool 26					
1992 (117)	21 (10)	15 (9)	—	2 (1)	—
1993 (66)	7 (2)	1 (1)	10 (2)	0 (0)	—
1994 (124)	21 (6)	5 (3)	14 (8)	1 (1)	—
1995 (69)[a]	—	—	—	—	—
1996 (112)	13 (10)	0 (0)	18 (9)	0 (0)	0 (0)
1997 (85)	16 (8)	1 (1)	13 (6)	0 (0)	1 (1)
1998 (72)	25 (16)	4 (4)	5 (2)	4 (3)	29 (24)
1999 (114)	28 (15)	1 (1)	9 (4)	1 (1)	2 (2)
Open River					
1992 (92)	22 (12)	5 (3)	—	1 (1)	—
1993[b]	—	—	—	—	—
1994 (84)	19 (9)	1 (1)	8 (4)	2 (1)	—
1995 (112)	12 (6)	0 (0)	14 (5)	1 (1)	2 (2)
1996 (107)	11 (6)	0 (0)	5 (2)	1 (1)	0 (0)
1997[b]	—	—	—	—	—
1998 (108)	12 (9)	0 (0)	4 (2)	1 (1)	20 (17)
1999 (108)	3 (2)	0 (0)	6 (3)	1 (1)	100 (74)
La Grange Pool					
1992 (102)	13 (6)	4 (2)	—	0 (0)	—
1993 (98)	11 (5)	17 (10)	52 (14)	0 (0)	—
1994 (126)	27 (9)	51 (13)	57 (10)	10 (3)	—
1995 (98)	5 (4)	15 (8)	32 (12)	1 (1)	9 (9)
1996 (98)	4 (2)	5 (3)	150 (50)	1 (1)	0 (0)
1997 (99)	8 (3)	9 (5)	101 (33)	0 (0)	0 (0)
1998 (99)	9 (6)	21 (12)	91 (25)	1 (1)	3 (1)
1999 (98)	9 (6)	13 (5)	46 (16)	0 (0)	0 (0)

[a]Sampling not completed because of high water levels.

[b]Area not sampled because of high water levels.

Table 4. Mean number of mayflies per square meter by study reach and aquatic area. *N* = number of samples.

Study reach (*N*)	Aquatic area			
	BWC[a] (±1 SE)	MCB[b] (±1 SE)	IMP[c] (±1 SE)	SC[d] (±1 SE)
Pool 4 (120)	65 (15)	0 (0)	74 (17)[e]	64 (49)
Pool 8 (107)	133 (47)	2 (2)	247 (43)	339 (134)
Pool 13 (118)	136 (40)	165 (89)	263 (37)	66 (43)
Pool 26 (114)	22 (21)	32 (16)	21 (6)	22 (12)
Open River (108)	—	3 (2)	—	3 (2)
La Grange Pool (98)	12 (7)	7 (5)	—	9 (3)

[a]BWC = contiguous backwater.
[b]MCB = main channel border.
[c]IMP = impounded.
[d]SC = side channel.
[e]Pool 4 IMP = Lake Pepin, Tributary Delta Lake.

Table 5. Mean number of fingernail clams per square meter by study reach and aquatic area. *N* = number of samples.

Study reach (*N*)	Aquatic area			
	BWC[a] (±1 SE)	MCB[b] (±1 SE)	IMP[c] (±1 SE)	SC[d] (±1 SE)
Pool 4 (120)	21 (6)	0 (0)	185 (27)[e]	0 (0)
Pool 8 (107)	75 (27)	131 (129)	861 (213)	321 (202)
Pool 13 (118)	95 (27)	10 (9)	260 (52)	15 (10)
Pool 26 (114)	3 (3)	1 (1)	6 (3)	1 (1)
Open River (108)	—	0 (0)	—	0 (0)
La Grange Pool (98)	18 (7)	9 (4)	—	32 (9)

[a]BWC = contiguous backwater.
[b]MCB = main channel border.
[c]IMP = impounded.
[d]SC = side channel.
[e]Pool 4 IMP = Lake Pepin, Tributary Delta Lake.

Table 6. Mean number of midges per square meter by study reach and aquatic area. *N* = number of samples.

Study reach (*N*)	Aquatic area			
	BWC[a] (±1 SE)	MCB[b] (±1 SE)	IMP[c] (±1 SE)	SC[d] (±1 SE)
Pool 4 (120)	107 (22)	56 (46)	243 (36)[e]	33 (17)
Pool 8 (107)	46 (16)	39 (34)	54 (14)	24 (7)
Pool 13 (118)	698 (220)	4 (4)	11 (4)	6 (4)
Pool 26 (114)	61 (20)	1 (1)	42 (10)	9 (7)
Open River (108)	—	6 (3)	—	2 (1)
La Grange Pool (98)	120 (43)	13 (4)	—	25 (7)

[a]BWC = contiguous backwater.
[b]MCB = main channel border.
[c]IMP = impounded.
[d]SC = side channel.
[e]Pool 4 IMP = Lake Pepin, Tributary Delta Lake.

Table 7. Mean number of zebra mussels per square meter by study reach and aquatic area. *N* = number of samples.

Study reach (*N*)	Aquatic area			
	BWC[a] (±1 SE)	MCB[b] (±1 SE)	IMP[c] (±1 SE)	SC[d] (±1 SE)
Pool 4 (120)	17 (10)	18 (14)	45 (40)[e]	21 (17)
Pool 8 (107)	34 (21)	81 (54)	447 (183)	326 (182)
Pool 13 (118)	171 (155)	399 (399)	974 (503)	12 (6)
Pool 26 (114)	0 (0)	2 (2)	7 (7)	0 (0)
Open River (108)	—	113 (84)	—	1 (1)
La Grange Pool (98)	0 (0)	1 (1)	—	0 (0)

[a]BWC = contiguous backwater.
[b]MCB = main channel border.
[c]IMP = impounded.
[d]SC = side channel.
[e]Pool 4 IMP = Lake Pepin, Tributary Delta Lake.

Table 8. Percentage of predominant substrate type found in Ponar grab samples by study reach. *N* = number of samples.

	Predominant substrate (%)					
Study reach (*N*)	**Hard clay**	**Silt clay**	**Silt clay with sand**	**Sand with silt clay**	**Sand**	**Gravel rock**
Pool 4 (120)	0.8	57.5	10.0	9.2	19.2	3.3
Pool 8 (107)	3.7	42.1	19.6	15.0	17.8	1.9
Pool 13 (118)	5.9	51.7	19.5	9.3	12.7	0.8
Pool 26 (114)	6.1	47.4	11.4	1.8	28.1	5.3
Open River (108)	0.9	3.7	11.1	6.5	62.0	15.7
La Grange Pool (98)	7.1	30.6	18.4	16.3	25.5	2.0

Table 9. Mean numbers of selected taxa per square meter by predominant substrate type, all study areas combined. *N* = number of samples.

Predominant substrate (*N*)	**Mayflies (±1 SE)**	**Fingernail clams (±1 SE)**	**Midges (±1 SE)**	**Asiatic clam (±1 SE)**	**Zebra mussels (±1 SE)**
Hard clay (27)	14 (5)	300 (181)	26 (9)	1 (1)	323 (189)
Silt clay (263)	163 (17)	148 (23)	166 (29)	0 (0)	153 (64)
Silt clay with sand (99)	97 (22)	275 (96)	116 (72)	1 (0)	129 (72)
Sand with silt clay (63)	25 (10)	33 (10)	44 (17)	1 (1)	52 (17)
Sand (181)	1 (1)	9 (7)	14 (6)	1 (0)	13 (10)
Gravel rock (32)	8 (6)	2 (2)	1 (1)	0 (0)	892 (605)

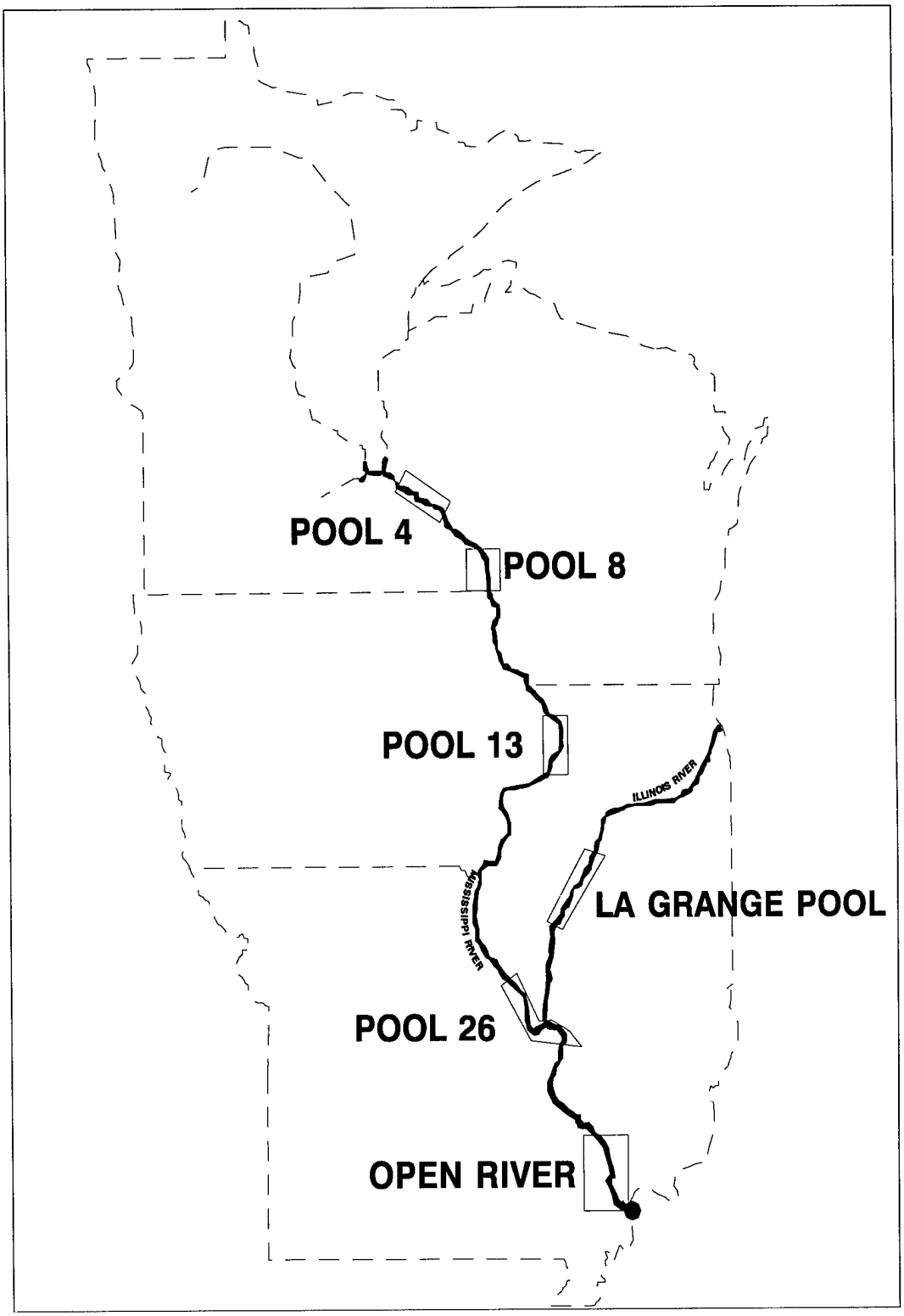


Figure 1. Long Term Resource Monitoring Program study reaches for macroinvertebrate sampling.

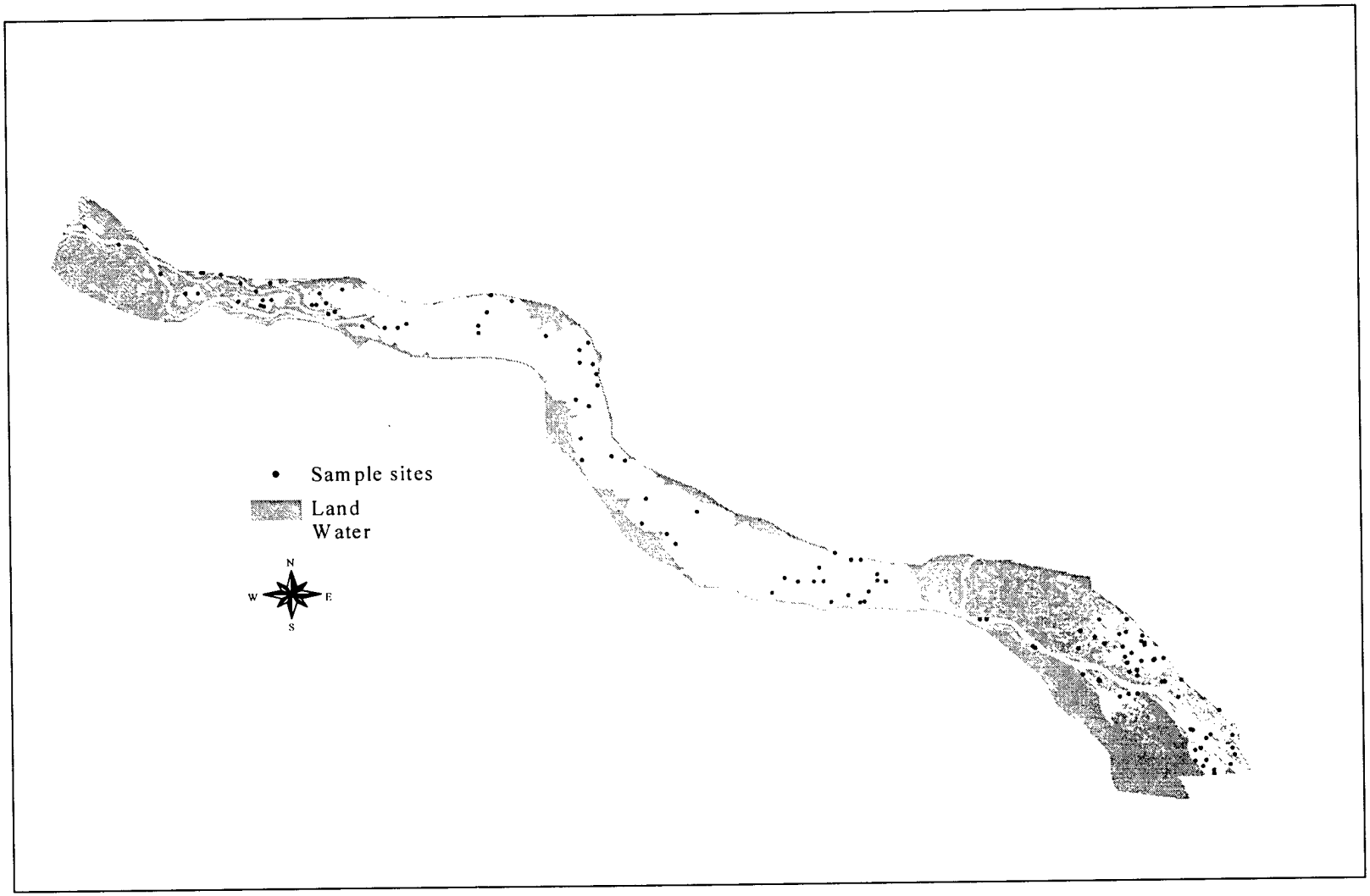


Figure 2. Pool 4 (Mississippi River miles 753–797)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points.

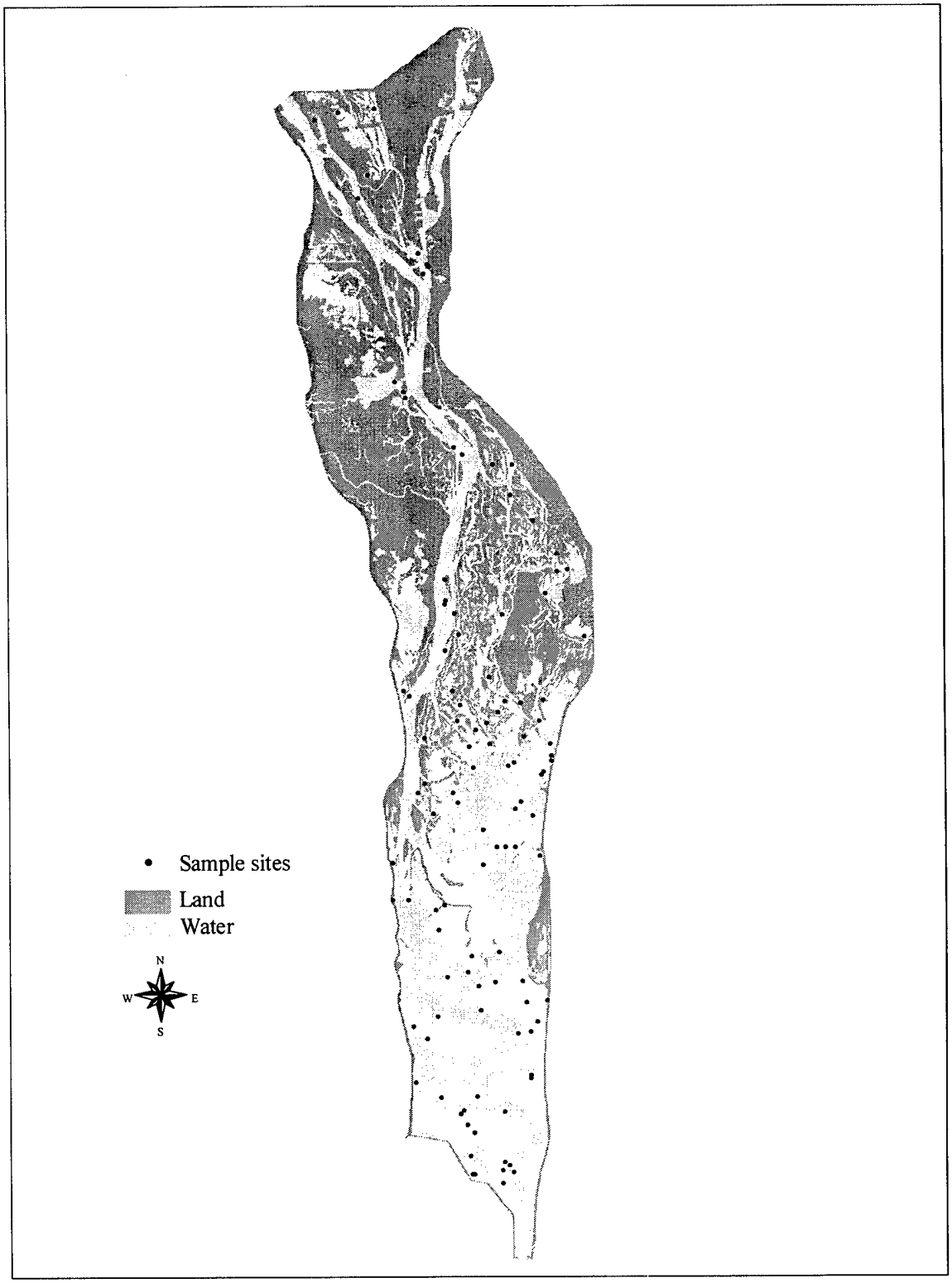


Figure 3. Pool 8 (Mississippi River miles 679–703)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points.

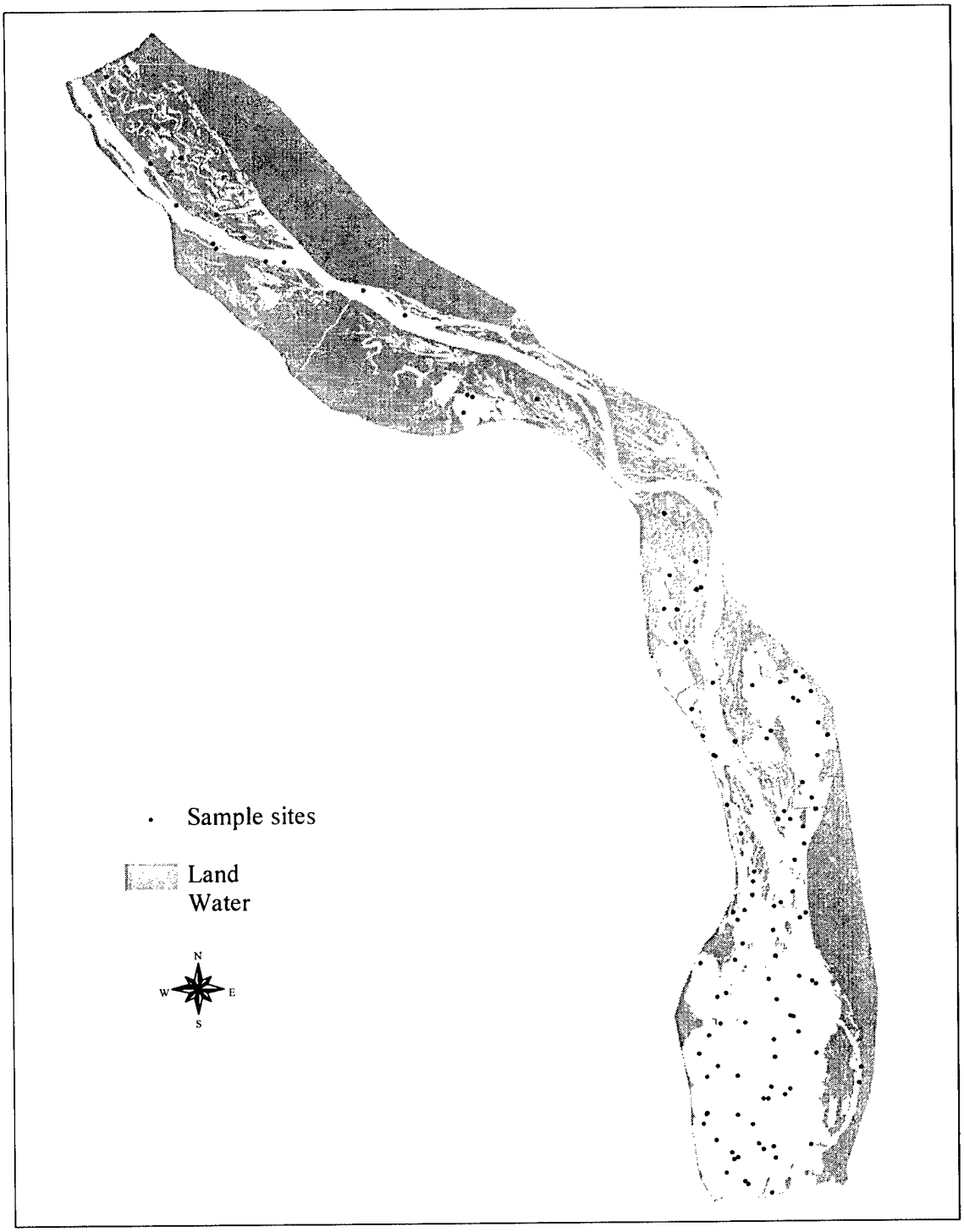


Figure 4. Pool 13 (Mississippi River miles 522.5–557)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points.

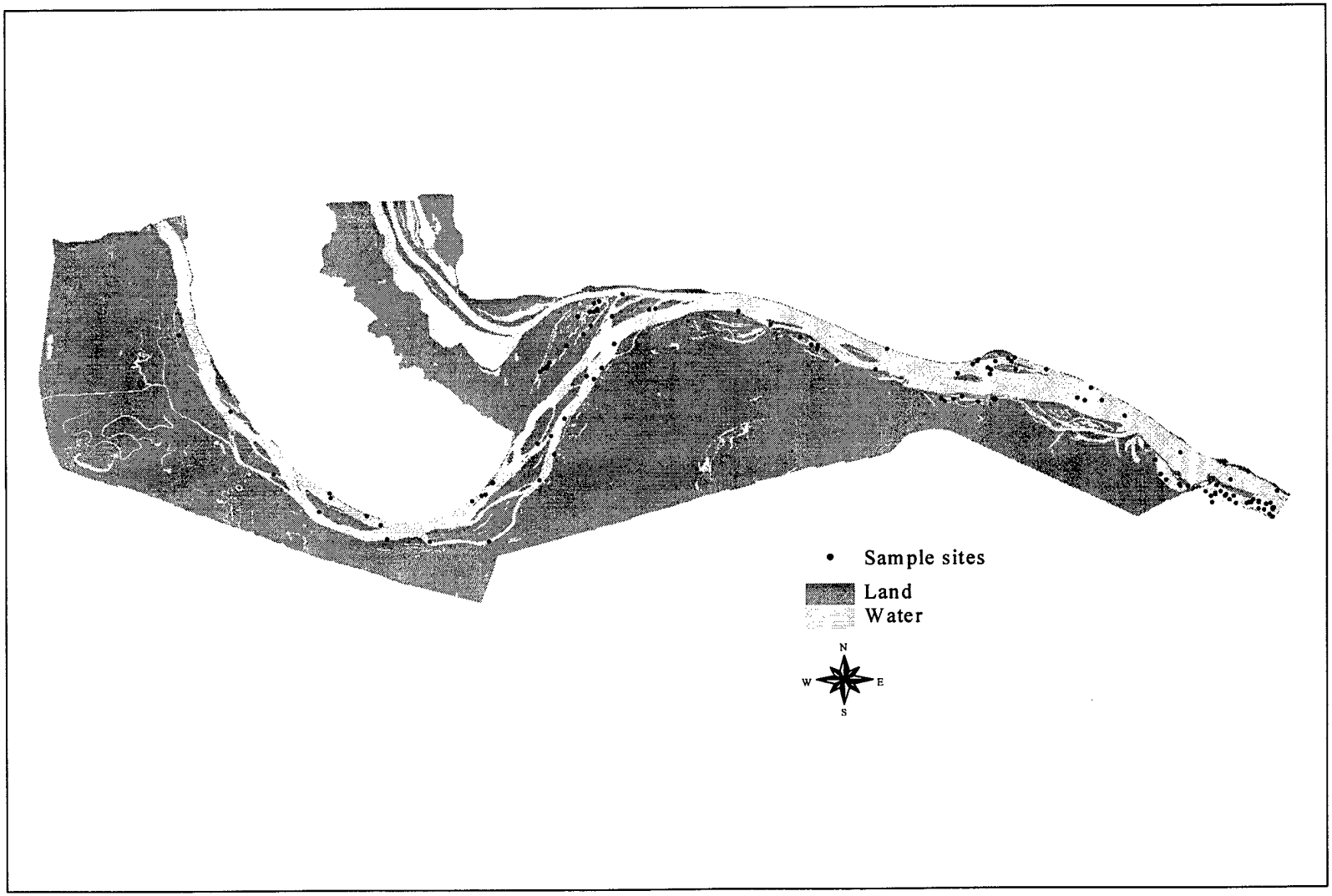


Figure 5. Pool 26 (Mississippi River miles 203–241.5)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points.

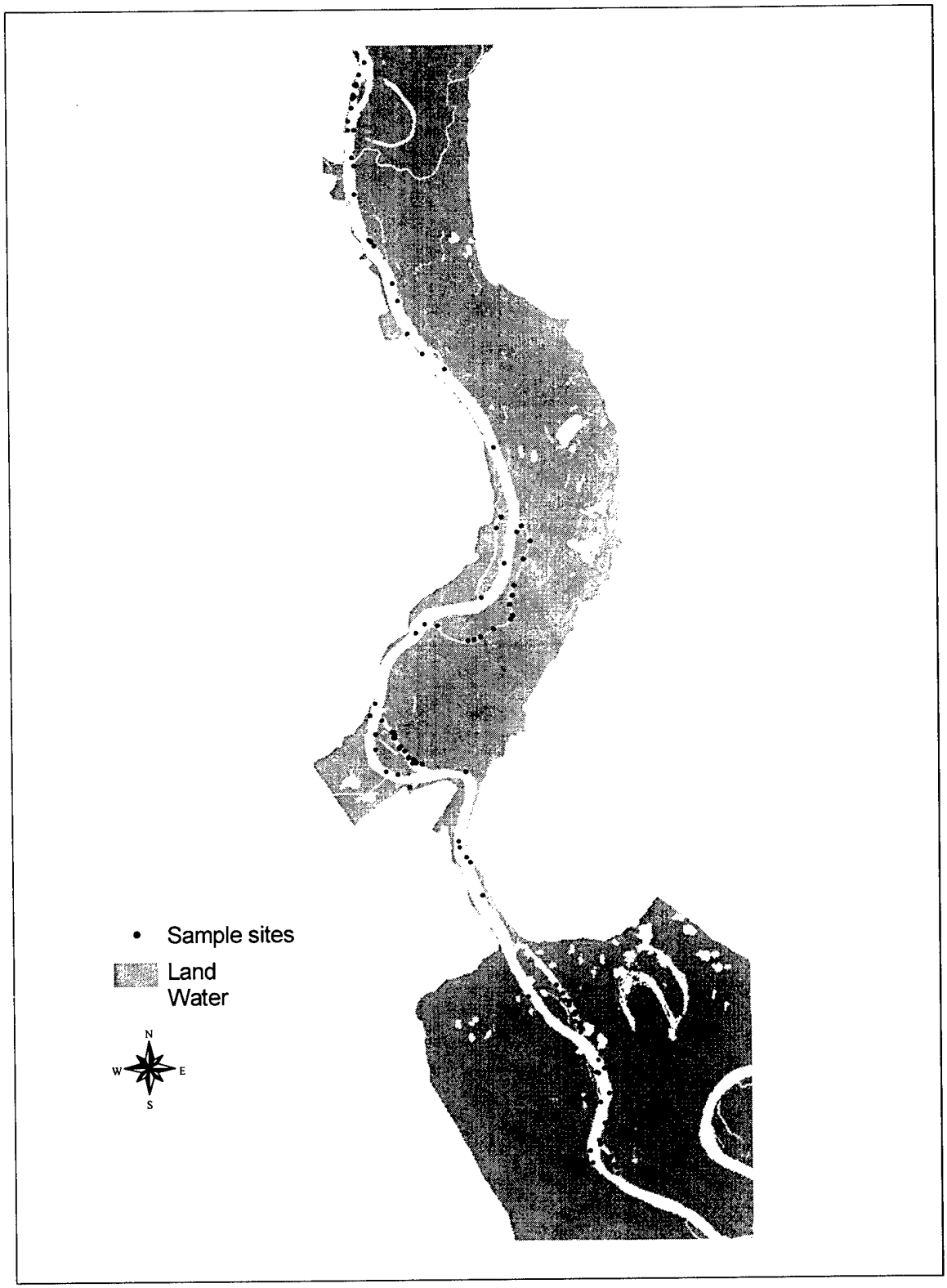


Figure 6. Open River (Mississippi River miles 0–80)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points.

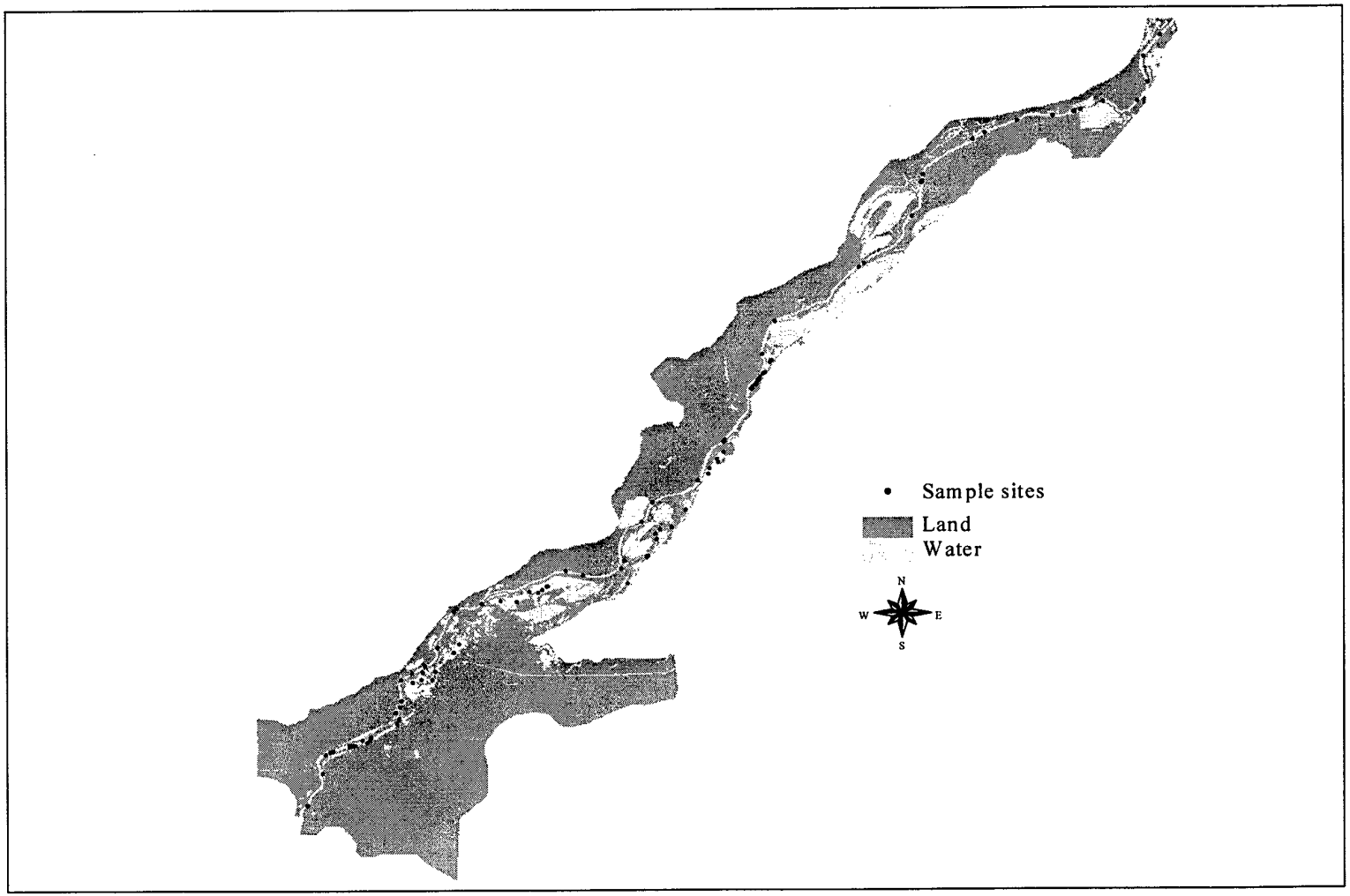


Figure 7. La Grange Pool (Illinois River miles 80–158)—1999 Long Term Resource Monitoring Program macroinvertebrate random sample points.

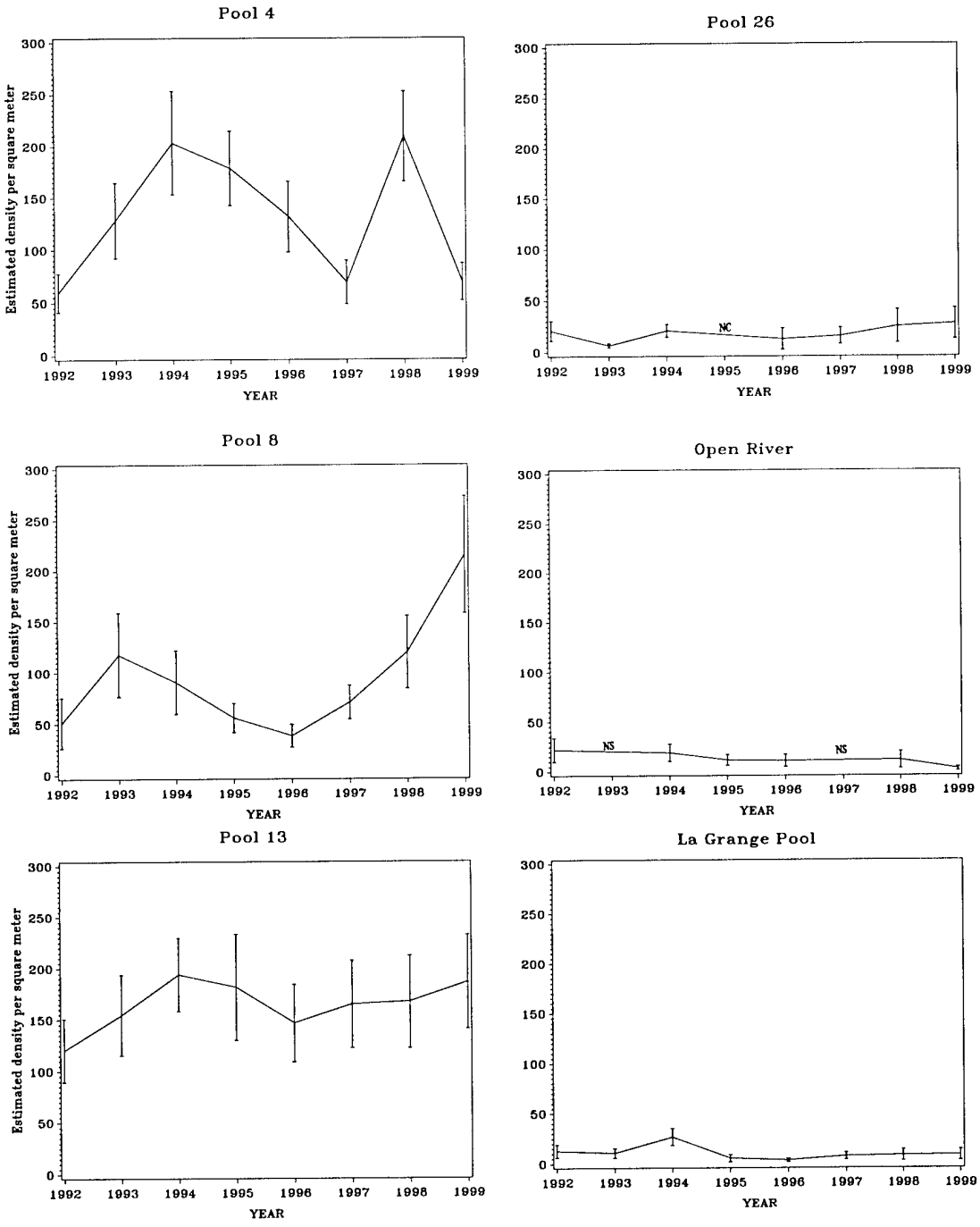


Figure 8. Estimated density of Ephemeridae (number m^{-2}) by study area, weighted by area of strata. Bars indicate ±1 standard error. NC = Sampling not completed because of high water levels; NS = Not sampled because of high water levels.

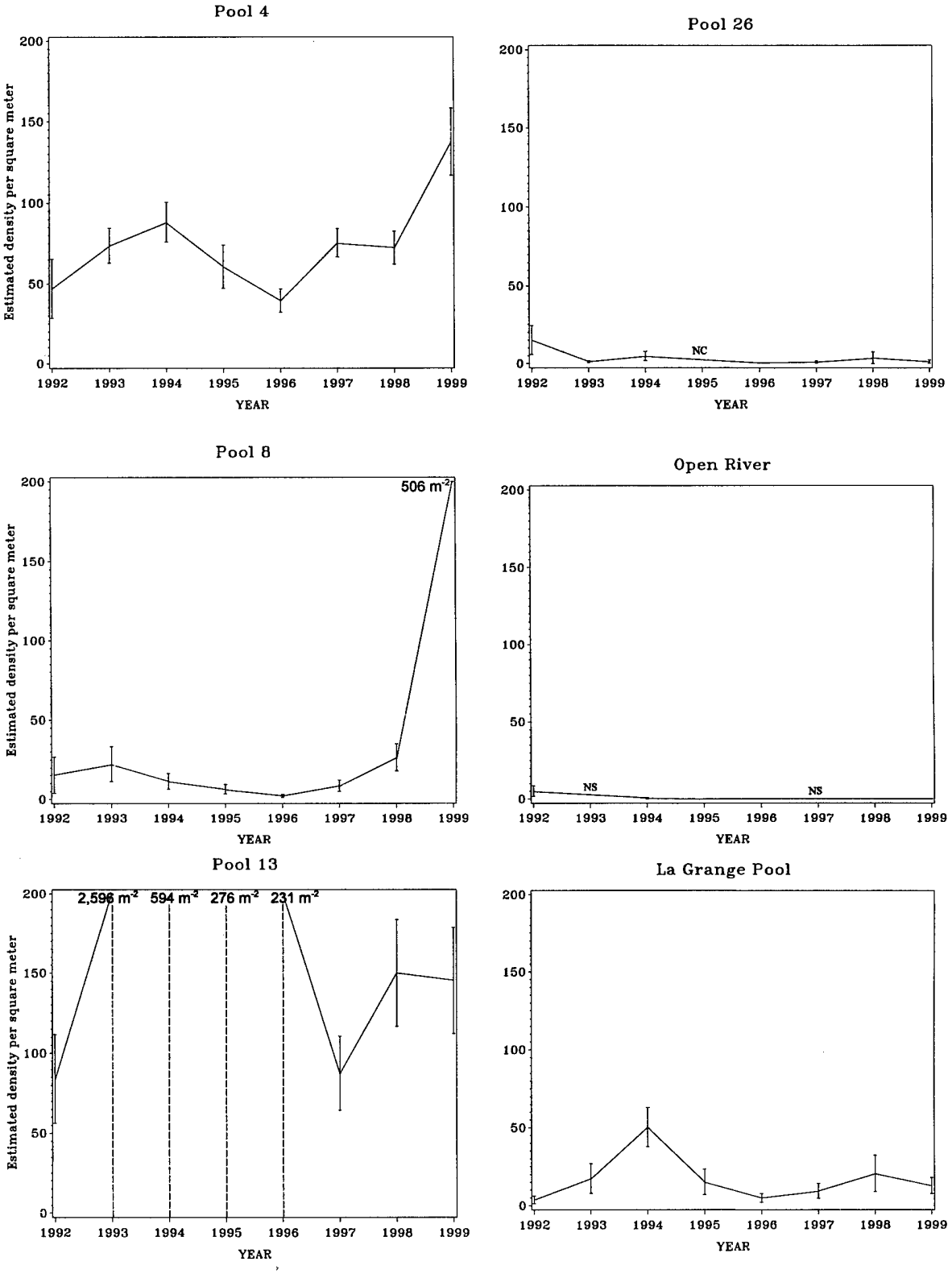


Figure 9. Estimated density of Sphaeriidae (number m^{-2}) by study area, weighted by area of strata. Bars indicate ±1 standard error. NC = Sampling not completed because of high water levels; NS = Not sampled because of high water levels.

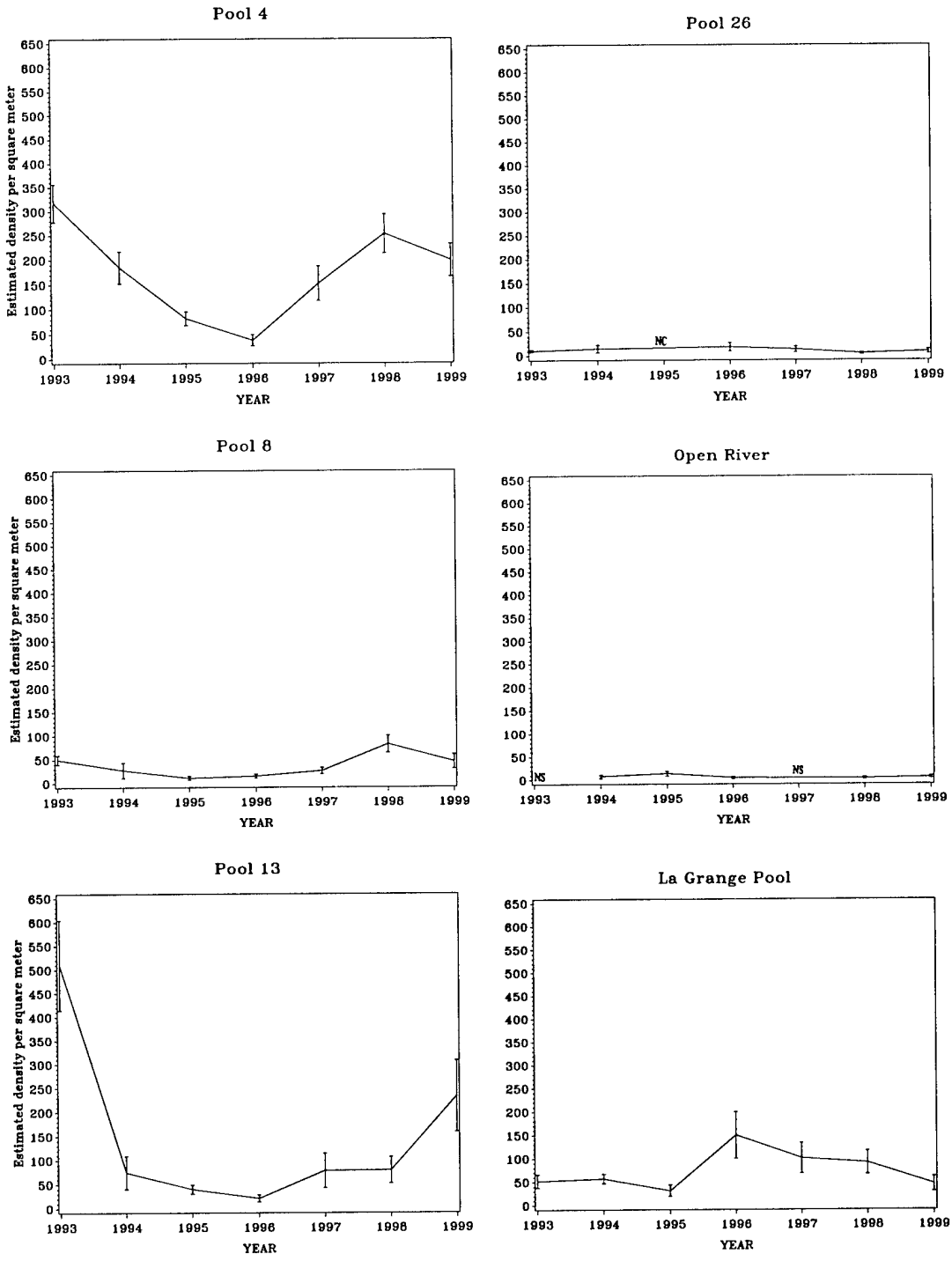


Figure 10. Estimated density of Chironomidae (number m^{-2}) by study area, weighted by area of strata. Bars indicate ±1 standard error. NC = Sampling not completed because of high water levels; NS = Not sampled because of high water levels.

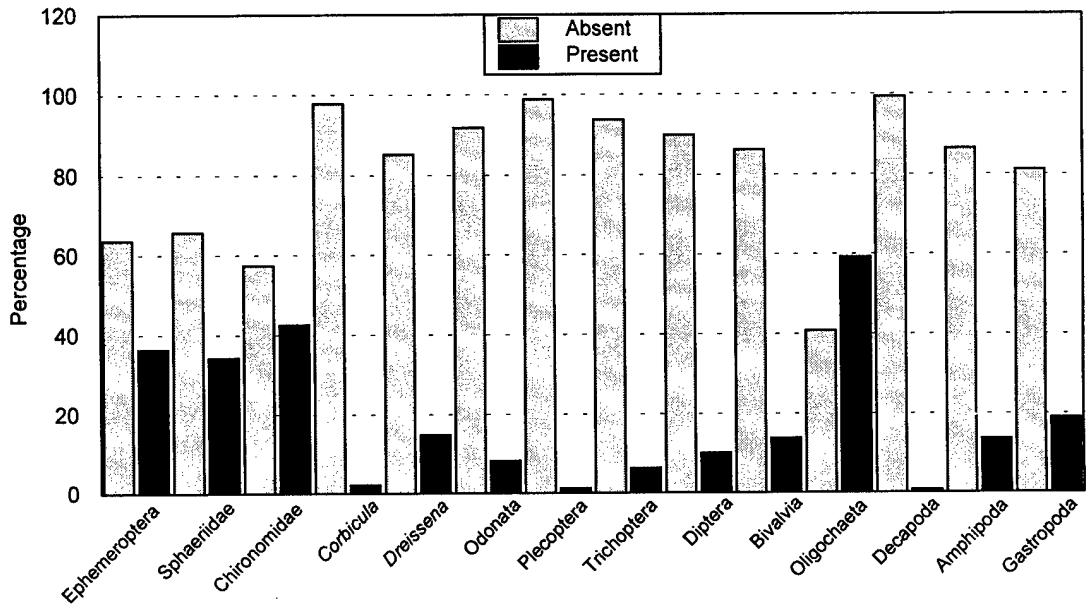


Figure 11. Percentage of times (all sample sites) that the taxa were recorded.

REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, D.C. 20503			
1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE Revised August 2000	3. REPORT TYPE AND DATES COVERED	
4. TITLE AND SUBTITLE Long Term Resource Monitoring Program annual status report, 1999: Macroinvertebrate sampling in six reaches of the Upper Mississippi River System.			5. FUNDING NUMBERS
6. AUTHOR(S) Jennifer S. Sauer			
7. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Geological Survey Upper Midwest Environmental Sciences Center 2630 Fanta Reed Road La Crosse, Wisconsin 54603			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Geological Survey Upper Midwest Environmental Sciences Center 2630 Fanta Reed Road La Crosse, Wisconsin 54603			10. SPONSORING/MONITORING AGENCY REPORT NUMBER 2000-P001 (Revised 2000)
11. SUPPLEMENTARY NOTES			
12a. DISTRIBUTION/AVAILABILITY STATEMENT Release unlimited. Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161 (1-800-553-6847 or 703-487-4650)			12b. DISTRIBUTION CODE
13. ABSTRACT (Maximum 200 words) In 1992, macroinvertebrate sampling was initiated in Pools 4, 8, 13, 26, and the Open River reach of the Mississippi River, and La Grange Pool of the Illinois River as part of the Long Term Resource Monitoring Program. Long-term monitoring is needed to detect population trends and local changes in aquatic ecosystems. Mayflies (Ephemeridae), fingernail clams (Sphaeriidae), and the exotic Asiatic clam (*Corbicula*) were selected for monitoring. Midges (Chironomidae) were added to the sampling design in 1993 and zebra mussels (*Dreissena polymorpha*) were added in 1995. Mayflies, fingernail clams, and midges, members of the soft-substrate community, were chosen because they play an important ecological role in the Upper Mississippi River System. Sampling was based on a stratified random design and was conducted at approximately 125 sites per study area. Mean densities of taxa were weighted by strata for extrapolation purposes. Pool 8 had the highest estimated mean densities of mayflies and fingernail clams (215 and 505 m^{-2}, respectively). Pool 13 had the highest estimated mean number of midges (234 m^{-2}). Overall, the impounded areas (including Lake Pepin) and the contiguous backwaters tended to support the highest mean densities of mayflies, fingernail clams, and midges. Substrates with predominantly a silt clay constituent supported the highest mean densities of mayflies, fingernail clams, and midges.			
14. SUBJECT TERMS Benthic aquatic macroinvertebrates, *Corbicula*, fingernail clams (Sphaeriidae), mayflies (Ephemeridae), midges (Chironomidae), Mississippi River, zebra mussels (*Dreissena polymorpha*)			15. NUMBER OF PAGES 21 pp. 16. PRICE CODE
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT

The Long Term Resource Monitoring Program (LTRMP) for the Upper Mississippi River System was authorized under the Water Resources Development Act of 1986 as an element of the Environmental Management Program. The mission of the LTRMP is to provide river managers with information for maintaining the Upper Mississippi River System as a sustainable large river ecosystem given its multiple-use character. The LTRMP is a cooperative effort by the U.S. Geological Survey, the U.S. Army Corps of Engineers, and the States of Illinois, Iowa, Minnesota, Missouri, and Wisconsin.